10088217 .071702 JC20 Rec'd PCT/PTO 18 MAR 2002

FORM PTO-1390 (REV. 5-93) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER **10191/2343**
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371	U S. APPLICATION NO. (If known, see 37 CFR 1.5) 10/088217

INTERNATIONAL APPLICATION NO	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED:
PCT/DE00/02912	**25 August 2000 (25.08.2000)**	**17 September 1999 (17.09.1999)**

TITLE OF INVENTION
EXHAUST GAS SENSOR FOR IGNITING AN EXOTHERMIC REACTION

APPLICANT(S) FOR DO/EO/US
Helmut WEYL, Konrad HENKELMANN and Wilhelm SORG

Applicants herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) immediately rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have. been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U S.C 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (unsigned).
10. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1 98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included
13. ☒ A **FIRST** preliminary amendment.
14. ☒ A substitute specification and marked-up version.
15. ☐ A change of power of attorney and/or address letter
16. ☒ Other items or information: International Search Report, International Preliminary Examination Report and PCT/RO/101.

Express Mail No 594613272

JC13 Rec'd PCT/PTO 18 MAR 2002

U.S. APPLICATION NO (if known, see 37 C.F.R.1.5) 10/088217	INTERNATIONAL APPLICATION NO PCT/DE00/02912	ATTORNEY'S DOCKET NUMBER 10191/2343

17. ☒ The following fees are submitted:

Basic National Fee (37 CFR 1.492(a)(1)-(5)):

	CALCULATIONS	PTO USE ONLY
Search Report has been prepared by the EUROPEAN PATENT OFFICE or JPO . . . $890.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) . . $710.00		
No international preliminary examination fee paid to USPTO (37 CFR 1 482) but international search fee paid to USPTO (37 CFR 1 445(a)(2)) . . . $740.00		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1 445(a)(2)) paid to USPTO . . . $1,040 00		
International preliminary examination fee paid to USPTO (37 CFR 1 482) and all claims satisfied provisions of PCT Article 33(2)-(4) . . . $100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890	
Surcharge of $130 00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1 492(e)).	$	

Claims	Number Filed	Number Extra	Rate	CALCULATIONS	PTO USE ONLY
Total Claims	12 - 20 =	0	X $18 00	$ 0	
Independent Claims	1 - 3 =	0	X $84.00	$ 0	
Multiple dependent claim(s) (if applicable)			+ $280.00	$ 0	

	CALCULATIONS	PTO USE ONLY
TOTAL OF ABOVE CALCULATIONS =	$ 890	
Reduction by ½ for filing by small entity, if applicable Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1 27, 1 28).	$ 0	
SUBTOTAL =	$ 890	
Processing fee of $130 00 for furnishing the English translation later the ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1 492(f)). +	$ 0	
TOTAL NATIONAL FEE =	$ 890	
Fee for recording the enclosed assignment (37 CFR 1 21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3 28, 3 31) $40.00 per property +	$	
TOTAL FEES ENCLOSED =	$ 890	
	Amount to be refunded	$
	charged	$

a. ☐ A check in the amount of $________ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 11-0600 in the amount of **$ 890.00** to cover the above fees. A duplicate copy of this sheet is enclosed

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600 A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1 495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO
Kenyon & Kenyon
One Broadway
New York, New York 10004

CUSTOMER NO. 26646

Richard L. Mayer by [signature] Reg. No. 42,194
SIGNATURE

Richard L. Mayer, Reg. No. 22,490
NAME

March 18, 2002
DATE

10 JC13 Rec'd PCT/PTO 18 MAR 2002

FORM PTO-1390 (REV. 5-93) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER 10191/2343
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371	U S APPLICATION NO (If known, see 37 CFR 1 5) 10/088217

INTERNATIONAL APPLICATION NO **PCT/DE00/02912**	INTERNATIONAL FILING DATE **25 August 2000 (25.08.2000)**	PRIORITY DATE CLAIMED **17 September 1999 (17.09.1999)**

TITLE OF INVENTION
EXHAUST GAS SENSOR FOR IGNITING AN EXOTHERMIC REACTION

APPLICANT(S) FOR DO/EO/US
Helmut WEYL, Konrad HENKELMANN and Wilhelm SORG

Applicants herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

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16. ☒ Other items or information: International Search Report, International Preliminary Examination Report and PCT/RO/101.

Express Mail No. 594613272

[10191/2343] #4/a

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	Helmut WEYL et al.
Serial No.	:	To Be Assigned
Filed	:	Herewith
For	:	EXHAUST GAS SENSOR FOR IGNITING AN EXOTHERMIC REACTION
Examiner	:	To Be Assigned
Art Unit	:	To Be Assigned

Assistant Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT AND
37 C.F.R. § 1.125 SUBSTITUTE SPECIFICATION STATEMENT

S I R:

Kindly amend the above-captioned application before examination, as set forth below.

IN THE SPECIFICATION AND ABSTRACT:

In accordance with 37 C.F.R. § 1.121(b)(3), a Substitute Specification (including the Abstract, but without claims) accompanies this response. It is respectfully requested that the Substitute Specification (including Abstract) be entered to replace the Specification of record.

IN THE CLAIMS:

On the first page of the claims, first line, change "What is claimed is:" to --WHAT IS CLAIMED IS:--.

Please cancel, without prejudice, claims 1 to 12 in the underlying PCT application. Please also cancel, without prejudice, claim 1 in the annex to the International Preliminary Examination Report.

EL594613272

Please add the following new claims:

--13. (New) An exhaust gas sensor, comprising:

a housing configured to be installed in an exhaust gas line of an engine;

a heating device; and

a ceramic sensor element mounted in the housing and heatable to a first temperature to measure an exhaust gas, the ceramic sensor element including the heating device; and

a heating power supply configured to supply, in a first operating phase, a high power for rapid heating of a section of the sensor element exposed to the exhaust gas to a second temperature sufficient to ignite a thermal afterburning of unburned constituents of the exhaust gas and to supply, in a subsequent second operating phase, a lower power to maintain the sensor element at the first temperature.

14. (New) The exhaust gas sensor according to claim 13, wherein the heating device includes two heating circuits, a first one of the heating circuits configured to maintain the first temperature, a second one of the heating circuits configured to rapidly heat to the second temperature.

15. (New) The exhaust gas sensor according to claim 14, wherein the housing includes a shielding body configured to protect the ceramic sensor element from direct oncoming flow of the exhaust gas, and the section of the sensor element heatable to the second temperature integrated into the shielding body.

16. (New) The exhaust gas sensor according to claim 15, wherein the first one of the heating circuits is arranged on the sensor element, and the second one of the heating circuits is arranged on the shielding body to ignite afterburning.

17. (New) The exhaust gas sensor according to claim 13, wherein the heating power supply is configured to deliver a pulsed heating current in the second operating phase.

18. (New) The exhaust gas sensor according to claim 13, wherein the heating power supply is configured to monitor an internal resistance of the sensor

element and to change from the first operating phase to the second operating phase when the internal resistance exceeds a limit value.

19. (New) The exhaust gas sensor according to claim 13, wherein the heating power supply is configured to monitor an internal resistance of the heating device and to change from the first operating phase to the second operating phase when the internal resistance exceeds a limit value.

20. (New) The exhaust gas sensor according to claim 18, wherein the heating power supply is configured to cyclically compare the internal resistance of the sensor element and the limit value during the first operating phase.

21. (New) The exhaust gas sensor according to claim 19, wherein the heating power supply is configured to cyclically compare the internal resistance of the heating device and the limit value during the first operating phase.

22. (New) The exhaust gas sensor according to claim 18, wherein the heating power supply is configured to change to the second operating phase after a predetermined maximum period of time, regardless of the internal resistance monitored.

23. (New) The exhaust gas sensor according to claim 19, wherein the heating power supply is configured to change to the second operating phase after a predetermined maximum period of time, regardless of the internal resistance monitored.

24. (New) The exhaust gas sensor according to claim 13, wherein the heating device is configured to reach the first temperature within a maximum heating time of five seconds.--.

REMARKS

This Preliminary Amendment cancels, without prejudice, claims 1 to 12 in the underlying PCT Application No. PCT/DE00/02912. This Preliminary Amendment further cancels, without prejudice, claim 1 in the annex to the

International Preliminary Examination Report and adds new claims 13 to 24. The new claims, inter alia, conform the claims to U.S. Patent and Trademark Office rules and does not add any new matter to the application.

In accordance with 37 C.F.R. § 1.121(b)(3), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. §§ 1.121(b)(3)(iii) and 1.125(b)(2), a Marked Up Version of the Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) is respectfully requested.

The underlying PCT Application No. PCT/DE00/02912 includes an International Search Report, dated December 27, 2000, a copy of which is included. The Search Report includes a list of documents that were considered by the Examiner in the underlying PCT application.

The underlying PCT Application No. PCT/DE00/02912 also includes an International Preliminary Examination Report, dated July 4, 2001. An English translation of the International Preliminary Examination Report and annex thereto is included herewith.

It is respectfully submitted that the subject matter of the present application is new, non-obvious and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully submitted,

KENYON & KENYON

Dated: March 18, 2002

By: Richard L. Mayer by [illegible] Reg. No. 42,194

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PATENT TRADEMARK OFFICE

[10191/2343]

EXHAUST GAS SENSOR FOR IGNITING AN EXOTHERMIC REACTION

FIELD OF THE INVENTION

The present invention relates to an exhaust gas sensor having a housing for installation in an exhaust gas line of an engine, a heating device and a sensor element which is mounted in the housing and is heatable to a first temperature suitable for measuring the exhaust gas.

BACKGROUND INFORMATION

Such an exhaust gas sensor is described in German Published Patent Application No. 41 26 378, for example.

Such sensors are used for regulating the air/fuel mixture supplied to the engine to achieve the lowest possible emissions in the exhaust gas in conjunction with a downstream catalytic converter.

To reliably maintain future exhaust gas limits, constant advances in the technology for exhaust gas aftertreatment will be necessary. An essential portion of the residual pollution emission of engines having a catalytic converter is eliminated even in the startup phase during which the catalytic converter has not yet reached the temperature required for efficient operation. Therefore, there has been a great deal of interest in which a catalytic converter may be heated as rapidly as possible to an operating temperature after starting the engine. Probably the most economical means of doing so is to use exothermic reactions, i.e., afterburning of unburned exhaust gas constituents such as CO and various hydrocarbons in the exhaust gas line between the outlet of the engine and the inlet of the catalytic converter. Structural changes in the exhaust gas line are expensive and usually cannot be implemented with engines that are already in operation, and they do not lead to the desired goal when used alone.

SUMMARY

The present invention relates to a method of utilizing the energy contained in the unburned exhaust gas constituents of the engine with little effort and within a short period of time after starting the engine for rapid heating of a catalytic converter without requiring structural changes in the exhaust gas line of the engine. To this end, only one exhaust gas sensor may be needed, having a heating power supply which in a first operating phase supplies a high power for rapid heating of a component of the exhaust gas sensor, which is exposed to the exhaust gas, to a second temperature sufficient to ignite a thermal afterburning of the unburned constituents, and in a subsequent second operating phase supplies a lower power to keep the sensor element at the first temperature. To achieve a definite reduction in pollution emissions in the startup phase with a traditional engine with catalytic converter, it is sufficient to replace the traditional exhaust gas sensor with an exhaust gas sensor according to the present invention.

The heating device may be divided into two heating circuits, the first of which is configured to maintain the first temperature, and the second of which is configured to rapidly heat to the second temperature. The first heating circuit is provided to be operated continuously as long as the engine is running, whereas the second heating circuit is to be operated only in the startup phase before the catalytic converter has reached its operating temperature, i.e., the first temperature.

According to a first example embodiment of the present invention, the component to be heated may be a section of the sensor element made of ceramic material. Such a sensor element traditionally includes a first heating device for heating a solid electrolyte enclosed between two measuring electrodes to a temperature at which a measurable ionic current, which depends on the oxygen content of the exhaust gas, is flowing

between the electrodes. According to one variant of this example embodiment, this heating device may include a single heating circuit which is configured for a greater heat output, making it possible to achieve the second temperature required for ignition of afterburning within a short period of time, e.g., in no more than 5 seconds.

According to a second example embodiment of the present invention, the housing of the exhaust gas sensor has a shielding body to protect the ceramic sensor element from direct oncoming flow of the exhaust gas and the solids contained in it, and the shielding body includes the component which is heatable to the second temperature. The heated shielding body may not only prevent direct contact of colder exhaust gases with the hot sensor element during the startup phase of the engine but may also preheat the portion of the exhaust gas reaching the sensor element, so that thermal shock may be prevented, which may otherwise result in cracking and thus destruction of the sensor element.

Delivery of a pulsed heating power by the heating power supply is a simple option for limiting the power delivered by the heating power supply during the second operating phase to a lower value than in the first operating phase.

To reliably detect the onset of the afterburning reaction, the heating power supply according to an example embodiment of the present invention monitors the internal resistance of the sensor element and changes from the first operating phase to the second operating phase when the internal resistance drops below a limit value. Since the ionic conductivity of the sensor element increases with an increase in temperature, a great reduction in the internal resistance of the sensor element corresponds to a definite increase in temperature, and if this temperature exceeds a value greater than what would be expected with the heat output used for the sensor element in

the absence of the afterburning reaction, this is a sign that afterburning is underway.

According to another example embodiment of the present invention, the internal resistance of the heating device, which increases with an increase in temperature, is utilized in that the heating power supply monitors the internal resistance, changing from the first operating phase to the second operating phase when the internal resistance exceeds a limit value which indicates the onset of the afterburning reaction.

To prevent an early switch to the second operating phase before afterburning is reliably underway, the comparison with the limit value may be performed cyclically and may thus be limited to individual discrete detection times.

To avoid overheating under anomalous conditions which may damage the exhaust gas sensor, the engine or the catalytic converter, the heating power supply may change to the second operating phase after a predetermined maximum period of time, regardless of the value of the internal resistance monitored.

Additional features of the present invention may be derived from the following description of example embodiments with reference to the figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an axial cross-sectional view through a portion of an exhaust gas sensor according to the present invention, mounted in a wall of an exhaust gas line.

Figure 2 is a schematic view of a heating device of an exhaust gas sensor and a heating power supply.

Figure 3 is a schematic view of an example embodiment of the heating device of a sensor.

DETAILED DESCRIPTION

Figure 1 illustrates head section 10 of an exhaust gas sensor in an axial section. It includes a metallic housing 12 having an outside thread 13 which is screwed tightly into a wall 14 of an exhaust gas line. A cylindrical longitudinal bore 15 contains a ceramic molding 20 having a continuous bore 24 with a rectangular cross-section in which is held a planar sensor element 26 and which is sealed by a tight packing 33, which is accommodated in a widened area 30 on the connection end of molded body 20. Contact fields 43 for picking up a measurement signal of the sensor element or for supplying a heating power for a heating device embedded in the interior of sensor element 26 and situated on the exhaust gas end 27 are located on the connection end of sensor element 26.

Exhaust gas end 27 of sensor element 26 projects out of housing 12 and is surrounded by a double-walled protective tube 40 having a plurality of gas inlet and outlet orifices 41.

Sensor element 26 is composed of a plurality of sintered ceramic layers which form porous measuring electrodes, a solid electrolyte in between and covering layers and insulation layers. A conductor which forms a resistance heating device is embedded between two insulation layers.

Figure 2 illustrates such a sensor 26 in a cross-sectional view along the plane of heating device 2. Heating device 2 traditionally includes a meandering heating element 3 arranged in close proximity to exhaust gas end 27 for heating the solid electrolyte and printed conductors 4 which connect meandering heating element 3 to contact fields 43 on the contact end of the sensor element. A heating power supply 5 is connected to these contact fields and a measuring instrument 6 is indicated schematically in one of the lines between heating power supply 5 and sensor element 26. The mode of operation of heating power supply 5 is graphically illustrated. Time t=0 at the

coordinate origin in the diagram corresponds to the starting of the engine. After this time, heating power supply 5 delivers a power supply voltage U to heating device 2 continuously at first. The power consumption by heating device 2 is measured with the help of measuring instrument 6, and power supply 5 compares the measured value with a predetermined limit value at regular intervals of approx. ½ to 1 second. In the course of heating the sensor element 26, the heating amperage at first decreases because the resistance of the heating device increases with an increase in self-heating. As soon as afterburning begins due to ignition of the unconsumed exhaust gas constituents by the glowing sensor element, this results in additional externally imposed heating of the heating device, which results in a further reduction in the heating amperage. The limit value is set so that it permits detection of the difference between these two stages of heating. The precise value of this limit value is to be selected as a function of the concrete use conditions of the sensor. A typical temperature at which afterburning begins may be in the range of approx. 800°C, but deviations in either direction are possible, depending on the concentration of unburned constituents in the exhaust gas and the residual oxygen content. The heat output is selected so that ignition is typically achieved within 3 to 4 seconds after the start of heating.

If this comparison indicates that the limit value has been reached or exceeded, heating power supply 5 changes from a first operating phase in which it supplies an elevated output voltage, which is continuous in this example embodiment, to a second operating phase in which it supplies a pulsed output voltage. As an alternative, it is also possible in the second operating phase to supply a continuous output voltage having a lower value than that in the first phase. The pulse duty factor of heating power supply 5 in the second operating phase is set to continuously maintain an operating temperature,

which is referred to as the first temperature and may be necessary for measurement operation of the sensor element.

If the limit value has not been exceeded after a predetermined maximum period of time of the first operating phase of 15 to 30 seconds, for example, then heating power supply 5 changes to the second operating phase, regardless of the measured value supplied by measuring instrument 6, to prevent damage to the sensor and its environment due to overheating.

Figure 3 illustrates a heating device 2' of a sensor element 26 according to one example embodiment of the present invention. The heating device includes two separate meandering heating elements 3' and 3", each connected by its own supply line 4', 4" to contact fields on the contact end of the sensor element. Meandering heating element 3" is arranged beneath measuring electrodes of sensor element 26 to heat them to their operating temperature.

Two meandering heating elements 3', 3" are each connected to separate outputs of a heating power supply, and the power consumption by one of them, e.g., meandering heating element 3', is measured with a measuring instrument as in the case illustrated in Figure 2. The measuring instrument is illustrated separately symbolically, but it may also be integrated into the heating power supply. The heating power supply has two operating phases, like that illustrated in Figure 2, namely a first operating phase which begins when the engine is started and lasts until the onset of the afterburning reaction may be inferred from the measured value of the amperage detected, or until a maximum duration of the first operating phase is exceeded, and a second operating phase which follows the first. In this second operating phase, the heating power supply interrupts the current to meandering heating element 3' and only maintains the current to meandering heating element 3". In this example embodiment of the exhaust gas sensor, exhaust gas end 27 of sensor element

26 is thus heated very rapidly, e.g., within a few seconds, to the temperature required to ignite afterburning by meandering heating element 3'.

The heating power supply may also supply a fixed output current instead of a fixed output voltage, in which case a voltage measuring instrument is used then as the measuring instrument to detect the heating power. Any other method of detecting the temperature is also possible.

According to alternative example embodiment of the present invention, the measuring instrument may also be arranged in the power circuit of the measuring electrode to detect an ionic current flowing between them as a function of temperature. This example embodiment is thus suitable in particular when a heating element is used for rapid heating of the sensor element to the afterburning temperature and also for maintaining an operating temperature as in the case illustrated in Figure 2.

According to another alternative example embodiment of the present invention, a heating element is mounted on a shielding body for rapid ignition of afterburning, and the shielding body also protects ceramic sensor element 26 from direct oncoming flow of cold exhaust gas in a startup phase of the engine, e.g., approximately at double-walled protective tube 40 from Figure 1. Such an example embodiment may reach a large exhaust gas volume and may heat it up within a short period of time while at the same time preheating a portion of the exhaust gas flow which reaches sensor element 26, thus effectively preventing thermal shock, which may cause cracking of the sensor element and thus its destruction. It is possible to detect the onset of afterburning on the basis of the temperature of the heated protective tube via the internal resistance of its integrated heating element. Analysis of the current in the measurement circuit of the ceramic exhaust gas sensor may also be possible because the sensor element is also

exposed to the exhaust gas flow, optionally heated to a greater extent by afterburning, and thus supplies a measurement current which depends on its temperature. At the time when the catalytic converter has reached its temperature required for catalytic afterburning, the heating power supply may have already switched to its second mode of operation or may have been shut down.

ABSTRACT

An exhaust gas sensor has a housing for installation in an exhaust gas line of an engine, having a heating device and a sensor element which is mounted in the housing and is heatable to a first temperature for measuring the exhaust gas. In a first operating phase, a heating power supply supplies a high power for rapid heating of a component of the exhaust gas sensor, which is exposed to the exhaust gas, to a second temperature sufficient to ignite afterburning of the exhaust gas, and in a subsequent second operating phase supplies a lower power to keep the sensor element at the first temperature.

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[10191/2343]

EXHAUST GAS SENSOR FOR IGNITING AN EXOTHERMIC REACTION

FIELD OF THE INVENTION

The present invention relates to an exhaust gas sensor having a housing for installation in an exhaust gas line of an engine, a heating device and a sensor element which is mounted in the housing and is heatable to a first temperature suitable for measuring the exhaust gas.

BACKGROUND INFORMATION

Such an exhaust gas sensor is [known from] **described in** German **Published** Patent Application **No.** 41 26 378 [A1], for example.

Such sensors are used for regulating the air/fuel mixture supplied to the engine to achieve the lowest possible emissions in the exhaust gas in conjunction with a downstream catalytic converter.

To reliably maintain future exhaust gas limits, constant advances in the technology for exhaust gas aftertreatment will be necessary. An essential portion of the residual pollution emission of engines having a catalytic converter is eliminated even in the startup phase during which the catalytic converter has not yet reached the temperature required for efficient operation. Therefore, there has been a great deal of interest in [means by] which [such] a catalytic converter may be heated as rapidly as possible to [its] **an** operating temperature after starting the engine. Probably the most economical means of doing so is to use exothermic reactions, i.e., afterburning of unburned exhaust gas constituents such as CO and various hydrocarbons in the exhaust gas line between the outlet of the engine and the inlet of the catalytic converter. Structural changes in the exhaust gas line [to this end] are expensive and usually cannot be implemented with engines that are

already in operation, and they do not lead to the desired goal when used alone.

[Advantages of the Invention
] **SUMMARY**

The present invention [describes] **relates to** a method of utilizing the energy contained in the unburned exhaust gas constituents of the engine with little effort and within a short period of time after starting the engine for rapid heating of a catalytic converter without requiring structural changes in the exhaust gas line of the engine. To this end, only one exhaust gas sensor [of the type defined at the beginning of the description is] **may be** needed, having a heating power supply which in a first operating phase supplies a high power for rapid heating of a component of the exhaust gas sensor, which is exposed to the exhaust gas, to a second temperature sufficient to ignite a thermal afterburning of the unburned constituents, and in a subsequent second operating phase supplies a lower power to keep the sensor element at the first temperature. To achieve a definite reduction in pollution emissions in the startup phase with a traditional engine with catalytic converter, it is sufficient to replace the traditional exhaust gas sensor with an exhaust gas sensor according to the present invention.

The heating device may be divided into two heating circuits, the first of which is [designed for maintaining] **configured to maintain** the first temperature, and the second of which is [designed for rapid heating] **configured to rapidly heat** to the second temperature. The first heating circuit is provided to be operated continuously as long as the engine is running, whereas the second heating circuit is to be operated only in the startup phase before the catalytic converter has reached its operating temperature, i.e., the first temperature.

According to a first **example** embodiment of the present invention, the component to be heated may be a section of the sensor element made of ceramic material. Such a sensor element traditionally includes a first heating device for heating a solid electrolyte enclosed between two measuring electrodes to a temperature at which a measurable ionic current, which depends on the oxygen content of the exhaust gas, is flowing between the electrodes. According to one variant of this **example** embodiment, this heating device may include a single heating circuit which is [designed] **configured** for a greater heat output, making it possible to achieve the second temperature required for ignition of afterburning within a short period of time, [preferably] **e.g.,** in no more than 5 seconds.

According to a second **example** embodiment of the present invention, the housing of the exhaust gas sensor has a shielding body to protect the ceramic sensor element from direct oncoming flow of the exhaust gas and the solids contained in it, and the shielding body includes the component which is heatable to the second temperature. [One advantage of this embodiment is that the] **The** heated shielding body **may** not only [prevents] **prevent** direct contact of colder exhaust gases with the hot sensor element during the startup phase of the engine but **may** also [preheats] **preheat** the portion of the exhaust gas reaching the sensor element, so that thermal shock [is] **may be** prevented, which [could] **may** otherwise result in cracking and thus destruction of the sensor element.

Delivery of a pulsed heating power by the heating power supply is a simple option for limiting the power delivered by the heating power supply during the second operating phase to a lower value than in the first operating phase.

To reliably detect the onset of the afterburning reaction, the heating power supply according to [a preferred variant] **an example embodiment of the present invention** monitors the internal resistance of the sensor element and changes from the first operating phase to the second operating phase when the internal resistance drops below a limit value. Since the ionic conductivity of the sensor element increases with an increase in temperature, a great reduction in the internal resistance of the sensor element corresponds to a definite increase in temperature, and if this temperature exceeds a value greater than what would be expected with the heat output used for the sensor element in the absence of the afterburning reaction, this is a sign that afterburning is underway.

According to [a second preferred variant] **another example embodiment of the present invention**, the internal resistance of the heating device, which increases with an increase in temperature, is utilized in that the heating power supply monitors the internal resistance, changing from the first operating phase to the second operating phase when the internal resistance exceeds a limit value which indicates the onset of the afterburning reaction.

To prevent an early switch to the second operating phase before afterburning is reliably underway, the comparison with the limit value may be performed cyclically and may thus be limited to individual discrete detection times.

To avoid overheating under anomalous conditions which [could] **may** damage the exhaust gas sensor, the engine or the catalytic converter, the heating power supply [should preferably] **may** change to the second operating phase after a predetermined maximum period of time, regardless of the value of the internal resistance monitored.

Additional [advantages and] features of the present invention [are] **may be** derived from the following description of **example** embodiments with reference to the figures.

[Brief Description of the Drawing
] **BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 [shows] **is** an axial [section] **cross-sectional view** through a portion of an exhaust gas sensor according to the present invention, mounted in a wall of an exhaust gas line[;]**.**

Figure 2 [shows] **is a schematic view of** a heating device of an exhaust gas sensor and a heating power supply[; and]**.**

[Figure 3 shows a variant] **Figure 3 is a schematic view of an example embodiment** of the heating device of a sensor.

DETAILED DESCRIPTION

Figure 1 [shows] **illustrates** head section 10 of an exhaust gas sensor in an axial section. It includes a metallic housing 12 having an outside thread 13 which is screwed tightly into a wall 14 of an exhaust gas line. A cylindrical longitudinal bore 15 contains a ceramic molding 20 having a continuous bore 24 with a rectangular [cross section] **cross-section** in which is held a planar sensor element 26 and which is sealed by a tight packing 33, which is accommodated in a widened area 30 on the connection end of molded body 20. Contact fields 43 for picking up a measurement signal of the sensor element or for supplying a heating power for a heating device embedded in the interior of sensor element 26 and situated on the exhaust gas end 27 are located on the connection end of sensor element 26.

Exhaust gas end 27 of sensor element 26 projects out of housing 12 and is surrounded by a double-walled protective

tube 40 having a plurality of gas inlet and outlet orifices 41.

Sensor element 26 is composed of a plurality of sintered ceramic layers which form porous measuring electrodes, a solid electrolyte in between [them] and covering layers and insulation layers. A conductor which forms a resistance heating device is embedded between two insulation layers.

Figure 2 illustrates such a sensor 26 in a [sectional] **cross-sectional** view along the plane of heating device 2. Heating device 2 traditionally includes a meandering heating element 3 [situated] **arranged** in close proximity to exhaust gas end 27 for heating the solid electrolyte and printed conductors 4 which connect meandering heating element 3 to contact fields 43 on the contact end of the sensor element. A heating power supply 5 is connected to these contact fields and a measuring instrument 6 is indicated schematically in one of the lines between heating power supply 5 and sensor element 26. [A diagram shown here illustrates the] **The** mode of operation of heating power supply 5 **is graphically illustrated**. Time t=0 at the coordinate origin in the diagram corresponds to the starting of the engine. After this time, heating power supply 5 delivers a power supply voltage U to heating device 2 continuously at first. The power consumption by heating device 2 is measured with the help of measuring instrument 6, and power supply 5 compares the measured value with a predetermined limit value at regular intervals of approx. ½ to 1 second. In the course of heating the sensor element 26, the heating amperage at first decreases because the resistance of the heating device increases with an increase in self-heating. As soon as afterburning begins due to ignition of the unconsumed exhaust gas constituents by the glowing sensor element, this results in additional externally imposed heating of the heating device, which [in turn] results in a further reduction in the heating amperage. The limit

value is set so that it permits detection of the difference between these two stages of heating. The precise value of this limit value is to be selected as a function of the concrete use conditions of the sensor. A typical temperature at which afterburning begins may be in the range of approx. 800°C, but deviations in either direction are possible, depending on the concentration of unburned constituents in the exhaust gas and the residual oxygen content. The heat output is selected so that ignition is typically achieved within 3 to 4 seconds after the start of heating.

If this comparison [shows] **indicates** that the limit value has been reached or exceeded, heating power supply 5 changes from [its] **a** first operating phase in which it supplies an elevated output voltage, which is continuous in this example **embodiment**, to a second operating phase in which it supplies a pulsed output voltage. As an alternative, it [would] **is** also [be] possible in the second operating phase to supply a continuous output voltage having a lower value than that in the first phase. The pulse duty factor of heating power supply 5 in the second operating phase is set to continuously maintain an operating temperature, which is referred to [here] as the first temperature and [is] **may be** necessary for measurement operation of the sensor element.

If the limit value has not been exceeded after a predetermined maximum period of time of the first operating phase of 15 to 30 seconds, for example, then heating power supply 5 changes to the second operating phase, regardless of the measured value supplied by measuring instrument 6, to prevent damage to the sensor and its environment due to overheating.

Figure 3 [shows] **illustrates** a heating device 2' of a sensor element 26 according to one [variant] **example embodiment** of the present invention. The heating device includes two separate meandering heating elements 3' and 3", each connected

by its own supply line 4', 4" to contact fields on the contact end of the sensor element. Meandering heating element 3" is [situated] **arranged** beneath measuring electrodes [(not shown)] of sensor element 26 to heat them to their operating temperature.

Two meandering heating elements 3', 3" are each connected to separate outputs of a heating power supply[(not shown)], and the power consumption by one of them, [preferably] **e.g.,** meandering heating element 3', is measured with a measuring instrument as in the case [of] **illustrated in** Figure 2. The measuring instrument is illustrated separately symbolically, but it may also [expediently] be integrated into the heating power supply. The heating power supply has two operating phases, like that **illustrated** in Figure 2, namely a first operating phase which begins when the engine is started and lasts until the onset of the afterburning reaction may be inferred from the measured value of the amperage detected, or until a maximum duration of the first operating phase is exceeded, and a second operating phase which follows the first. In this second operating phase, the heating power supply interrupts the current to meandering heating element 3' and only maintains the current to meandering heating element 3". In this [variant] **example embodiment** of the exhaust gas sensor, exhaust gas end 27 of sensor element 26 is thus heated very rapidly, [preferably] **e.g.,** within a few seconds, to the temperature required to ignite afterburning by meandering heating element 3'.

The heating power supply may [of course] also supply a fixed output current instead of a fixed output voltage, in which case a voltage measuring instrument is used then as the measuring instrument to detect the heating power. Any other method of detecting the temperature is also [suitable] **possible**.

According to [another] alternative **example embodiment of the present invention**, the measuring instrument [could] **may** also be arranged in the power circuit of the measuring electrode to detect an ionic current flowing between them as a function of temperature. This [variant] **example embodiment** is thus suitable in particular when a heating element is used for rapid heating of the sensor element to the afterburning temperature and also for maintaining an operating temperature as in the case [of] **illustrated in** Figure 2.

According to another alternative **example** embodiment **of the present invention**, a heating element is mounted on a shielding body for rapid ignition of afterburning, and the shielding body also protects ceramic sensor element 26 from direct oncoming flow of cold exhaust gas in a startup phase of the engine, e.g., approximately at double-walled protective tube 40 from Figure 1. Such [a variant has the advantage that it reaches] **an example embodiment may reach** a large exhaust gas volume and [heats] **may heat** it up within a short period of time while at the same time preheating a portion of the exhaust gas flow which reaches sensor element 26, thus effectively preventing thermal shock, which [could] **may** cause cracking of the sensor element and thus its destruction. [Here again, it] **It** is possible to detect the onset of afterburning on the basis of the temperature of the heated protective tube via the internal resistance of its integrated heating element. Analysis of the current in the measurement circuit of the ceramic exhaust gas sensor [would] **may** also be [a possibility] **possible** because the sensor element is also exposed to the exhaust gas flow, optionally heated to a greater extent by afterburning, and thus supplies a measurement current which depends on its temperature. At the time when the catalytic converter has reached its temperature required for catalytic afterburning, the heating power supply may have already

switched to its second mode of operation or [it] may have been shut down.

[Abstract

] **ABSTRACT**

An exhaust gas sensor has a housing for installation in an exhaust gas line of an engine, having a heating device [(2)] and a sensor element [(26)] which is mounted in the housing and is heatable to a first temperature for measuring the exhaust gas. In a first operating phase, a heating power supply [(5)] supplies a high power for rapid heating of a component of the exhaust gas sensor[(26)], which is exposed to the exhaust gas, to a second temperature sufficient to ignite afterburning of the exhaust gas, and in a subsequent second operating phase supplies a lower power to keep the sensor element [(26)] at the first temperature.[

Figure 2]

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JC13 Rec'd PCT/PTO 18 MAR 2002

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[10191/2343]

EXHAUST GAS SENSOR FOR IGNITING AN EXOTHERMIC REACTION

The present invention relates to an exhaust gas sensor having a housing for installation in an exhaust gas line of an engine, a heating device and a sensor element which is mounted in the housing and is heatable to a first temperature suitable for measuring the exhaust gas. Such an exhaust gas sensor is known from German Patent Application 41 26 378 A1, for example.

Such sensors are used for regulating the air/fuel mixture supplied to the engine to achieve the lowest possible emissions in the exhaust gas in conjunction with a downstream catalytic converter.

To reliably maintain future exhaust gas limits, constant advances in the technology for exhaust gas aftertreatment will be necessary. An essential portion of the residual pollution emission of engines having a catalytic converter is eliminated even in the startup phase during which the catalytic converter has not yet reached the temperature required for efficient operation. Therefore, there has been a great deal of interest in means by which such a catalytic converter may be heated as rapidly as possible to its operating temperature after starting the engine. Probably the most economical means of doing so is to use exothermic reactions, i.e., afterburning of unburned exhaust gas constituents such as CO and various hydrocarbons in the exhaust gas line between the outlet of the engine and the inlet of the catalytic converter. Structural changes in the exhaust gas line to this end are expensive and usually cannot be implemented with engines that are already in operation, and they do not lead to the desired goal when used alone.

Advantages of the Invention

The present invention describes a method of utilizing the energy contained in the unburned exhaust gas constituents of the engine with little effort and within a short period of time after starting the engine for rapid heating of a catalytic converter without requiring structural changes in the exhaust gas line of the engine. To this end, only one exhaust gas sensor of the type defined at the beginning of the description is needed, having a heating power supply which in a first operating phase supplies a high power for rapid heating of a component of the exhaust gas sensor, which is exposed to the exhaust gas, to a second temperature sufficient to ignite a thermal afterburning of the unburned constituents, and in a subsequent second operating phase supplies a lower power to keep the sensor element at the first temperature. To achieve a definite reduction in pollution emissions in the startup phase with a traditional engine with catalytic converter, it is sufficient to replace the traditional exhaust gas sensor with an exhaust gas sensor according to the present invention.

The heating device may be divided into two heating circuits, the first of which is designed for maintaining the first temperature, and the second of which is designed for rapid heating to the second temperature. The first heating circuit is provided to be operated continuously as long as the engine is running, whereas the second heating circuit is to be operated only in the startup phase before the catalytic converter has reached its operating temperature, i.e., the first temperature.

According to a first embodiment of the present invention, the component to be heated may be a section of the sensor element made of ceramic material. Such a sensor element traditionally includes a first heating device for heating a solid electrolyte enclosed between two measuring electrodes to a

temperature at which a measurable ionic current, which depends on the oxygen content of the exhaust gas, is flowing between the electrodes. According to one variant of this embodiment, this heating device may include a single heating circuit which is designed for a greater heat output, making it possible to achieve the second temperature required for ignition of afterburning within a short period of time, preferably in no more than 5 seconds.

According to a second embodiment of the present invention, the housing of the exhaust gas sensor has a shielding body to protect the ceramic sensor element from direct oncoming flow of the exhaust gas and the solids contained in it, and the shielding body includes the component which is heatable to the second temperature. One advantage of this embodiment is that the heated shielding body not only prevents direct contact of colder exhaust gases with the hot sensor element during the startup phase of the engine but also preheats the portion of the exhaust gas reaching the sensor element, so that thermal shock is prevented, which could otherwise result in cracking and thus destruction of the sensor element.

Delivery of a pulsed heating power by the heating power supply is a simple option for limiting the power delivered by the heating power supply during the second operating phase to a lower value than in the first operating phase.

To reliably detect the onset of the afterburning reaction, the heating power supply according to a preferred variant monitors the internal resistance of the sensor element and changes from the first operating phase to the second operating phase when the internal resistance drops below a limit value. Since the ionic conductivity of the sensor element increases with an increase in temperature, a great reduction in the internal resistance of the sensor element corresponds to a definite increase in temperature, and if this temperature exceeds a value greater than what would be expected with the heat output

used for the sensor element in the absence of the afterburning reaction, this is a sign that afterburning is underway.

According to a second preferred variant, the internal resistance of the heating device, which increases with an increase in temperature, is utilized in that the heating power supply monitors the internal resistance, changing from the first operating phase to the second operating phase when the internal resistance exceeds a limit value which indicates the onset of the afterburning reaction.

To prevent an early switch to the second operating phase before afterburning is reliably underway, the comparison with the limit value may be performed cyclically and may thus be limited to individual discrete detection times.

To avoid overheating under anomalous conditions which could damage the exhaust gas sensor, the engine or the catalytic converter, the heating power supply should preferably change to the second operating phase after a predetermined maximum period of time, regardless of the value of the internal resistance monitored.

Additional advantages and features of the present invention are derived from the following description of embodiments with reference to the figures.

Brief Description of the Drawing

Figure 1 shows an axial section through a portion of an exhaust gas sensor according to the present invention, mounted in a wall of an exhaust gas line;

Figure 2 shows a heating device of an exhaust gas sensor and a heating power supply; and

Figure 3 shows a variant of the heating device of a sensor.

Figure 1 shows head section 10 of an exhaust gas sensor in an axial section. It includes a metallic housing 12 having an outside thread 13 which is screwed tightly into a wall 14 of an exhaust gas line. A cylindrical longitudinal bore 15 contains a ceramic molding 20 having a continuous bore 24 with a rectangular cross section in which is held a planar sensor element 26 and which is sealed by a tight packing 33, which is accommodated in a widened area 30 on the connection end of molded body 20. Contact fields 43 for picking up a measurement signal of the sensor element or for supplying a heating power for a heating device embedded in the interior of sensor element 26 and situated on the exhaust gas end 27 are located on the connection end of sensor element 26.

Exhaust gas end 27 of sensor element 26 projects out of housing 12 and is surrounded by a double-walled protective tube 40 having a plurality of gas inlet and outlet orifices 41.

Sensor element 26 is composed of a plurality of sintered ceramic layers which form porous measuring electrodes, a solid electrolyte in between them and covering layers and insulation layers. A conductor which forms a resistance heating device is embedded between two insulation layers.

Figure 2 illustrates such a sensor 26 in a sectional view along the plane of heating device 2. Heating device 2 traditionally includes a meandering heating element 3 situated in close proximity to exhaust gas end 27 for heating the solid electrolyte and printed conductors 4 which connect meandering heating element 3 to contact fields 43 on the contact end of the sensor element. A heating power supply 5 is connected to these contact fields and a measuring instrument 6 is indicated schematically in one of the lines between heating power supply 5 and sensor element 26. A diagram shown here illustrates the mode of operation of heating power supply 5. Time t=0 at the coordinate origin in the diagram corresponds to the starting

of the engine. After this time, heating power supply 5 delivers a power supply voltage U to heating device 2 continuously at first. The power consumption by heating device 2 is measured with the help of measuring instrument 6, and power supply 5 compares the measured value with a predetermined limit value at regular intervals of approx. ½ to 1 second. In the course of heating the sensor element 26, the heating amperage at first decreases because the resistance of the heating device increases with an increase in self-heating. As soon as afterburning begins due to ignition of the unconsumed exhaust gas constituents by the glowing sensor element, this results in additional externally imposed heating of the heating device, which in turn results in a further reduction in the heating amperage. The limit value is set so that it permits detection of the difference between these two stages of heating. The precise value of this limit value is to be selected as a function of the concrete use conditions of the sensor. A typical temperature at which afterburning begins may be in the range of approx. 800°C, but deviations in either direction are possible, depending on the concentration of unburned constituents in the exhaust gas and the residual oxygen content. The heat output is selected so that ignition is typically achieved within 3 to 4 seconds after the start of heating.

If this comparison shows that the limit value has been reached or exceeded, heating power supply 5 changes from its first operating phase in which it supplies an elevated output voltage, which is continuous in this example, to a second operating phase in which it supplies a pulsed output voltage. As an alternative, it would also be possible in the second operating phase to supply a continuous output voltage having a lower value than that in the first phase. The pulse duty factor of heating power supply 5 in the second operating phase is set to continuously maintain an operating temperature, which is referred to here as the first temperature and is necessary for measurement operation of the sensor element.

If the limit value has not been exceeded after a predetermined maximum period of time of the first operating phase of 15 to 30 seconds, for example, then heating power supply 5 changes to the second operating phase, regardless of the measured value supplied by measuring instrument 6, to prevent damage to the sensor and its environment due to overheating.

Figure 3 shows a heating device 2' of a sensor element 26 according to one variant of the present invention. The heating device includes two separate meandering heating elements 3' and 3", each connected by its own supply line 4', 4" to contact fields on the contact end of the sensor element. Meandering heating element 3" is situated beneath measuring electrodes (not shown) of sensor element 26 to heat them to their operating temperature.

Two meandering heating elements 3', 3" are each connected to separate outputs of a heating power supply (not shown), and the power consumption by one of them, preferably meandering heating element 3', is measured with a measuring instrument as in the case of Figure 2. The measuring instrument is illustrated separately symbolically, but it may also expediently be integrated into the heating power supply. The heating power supply has two operating phases, like that in Figure 2, namely a first operating phase which begins when the engine is started and lasts until the onset of the afterburning reaction may be inferred from the measured value of the amperage detected, or until a maximum duration of the first operating phase is exceeded, and a second operating phase which follows the first. In this second operating phase, the heating power supply interrupts the current to meandering heating element 3' and only maintains the current to meandering heating element 3". In this variant of the exhaust gas sensor, exhaust gas end 27 of sensor element 26 is thus heated very rapidly, preferably within a few seconds, to the temperature required to ignite afterburning by meandering heating element 3'.

The heating power supply may of course also supply a fixed output current instead of a fixed output voltage, in which case a voltage measuring instrument is used then as the measuring instrument to detect the heating power. Any other method of detecting the temperature is also suitable.

According to another alternative, the measuring instrument could also be arranged in the power circuit of the measuring electrode to detect an ionic current flowing between them as a function of temperature. This variant is thus suitable in particular when a heating element is used for rapid heating of the sensor element to the afterburning temperature and also for maintaining an operating temperature as in the case of Figure 2.

According to another alternative embodiment, a heating element is mounted on a shielding body for rapid ignition of afterburning, and the shielding body also protects ceramic sensor element 26 from direct oncoming flow of cold exhaust gas in a startup phase of the engine, e.g., approximately at double-walled protective tube 40 from Figure 1. Such a variant has the advantage that it reaches a large exhaust gas volume and heats it up within a short period of time while at the same time preheating a portion of the exhaust gas flow which reaches sensor element 26, thus effectively preventing thermal shock, which could cause cracking of the sensor element and thus its destruction. Here again, it is possible to detect the onset of afterburning on the basis of the temperature of the heated protective tube via the internal resistance of its integrated heating element. Analysis of the current in the measurement circuit of the ceramic exhaust gas sensor would also be a possibility because the sensor element is also exposed to the exhaust gas flow, optionally heated to a greater extent by afterburning, and thus supplies a measurement current which depends on its temperature. At the time when the catalytic converter has reached its temperature required for catalytic afterburning, the heating power supply

may have already switched to its second mode of operation or it may have been shut down.

What is claimed is:

1. An exhaust gas sensor having a housing (12) for installation in an exhaust gas line of an engine, having a heating device (2, 2') and a sensor element (26) which is mounted in the housing (12) and is heatable to a first temperature for measuring the exhaust gas, characterized by a heating power supply (5) which, in a first operating phase, supplies a high power for rapid heating of a component (26, 40) of the exhaust gas sensor, which is exposed to the exhaust gas, to a second temperature sufficient to ignite a thermal afterburning of unburned constituents of the exhaust gas; and, in a subsequent second operating phase, supplies a lower power to keep the sensor element (26) at the first temperature.

2. The exhaust gas sensor according to Claim 1, wherein the heating device (2') includes two heating circuits (3', 3"), the first (3") of which is designed for maintaining the first temperature, and the second (3') of which is designed for rapid heating to the second temperature.

3. The exhaust gas sensor according to Claim 1 or 2, wherein the component is a section of the ceramic sensor element (26).

4. The exhaust gas sensor according to Claim 3, wherein the ceramic sensor element (26) includes the heating device (2, 2').

5. The exhaust gas sensor according to Claim 2, wherein the housing has a shielding body (40) to protect the ceramic sensor element (26) from direct oncoming flow of the exhaust gas, and the component, which is heatable to the second temperature, is integrated into the shielding body (40).

6. The exhaust gas sensor according to Claim 5, wherein the first heating element is situated on the sensor element, and the second heating element is situated on the shielding body to ignite afterburning.

7. The exhaust gas sensor according to one of the preceding claims, wherein the heating power supply (5) delivers a pulsed heating current in the second operating phase.

8. The exhaust gas sensor according to one of the preceding claims, wherein the heating power supply (5) monitors the internal resistance of the sensor element and changes from the first operating phase to the second operating phase when the internal resistance exceeds a limit value.

9. The exhaust gas sensor according to one of Claims 1 through 7, wherein the heating power supply monitors the internal resistance of the heating device (2, 2') and changes from the first operating phase to the second operating phase when the internal resistance exceeds a limit value.

10. The exhaust gas sensor according to Claim 8 or 9, wherein the heating power supply (5) makes the comparison cyclically during the first operating phase.

11. The exhaust gas sensor according to one of Claims 8 through 10, wherein the heating power supply (5) changes to the second operating phase after a predetermined maximum period of time, regardless of the internal resistance monitored.

12. The exhaust gas sensor according to one of the preceding claims,

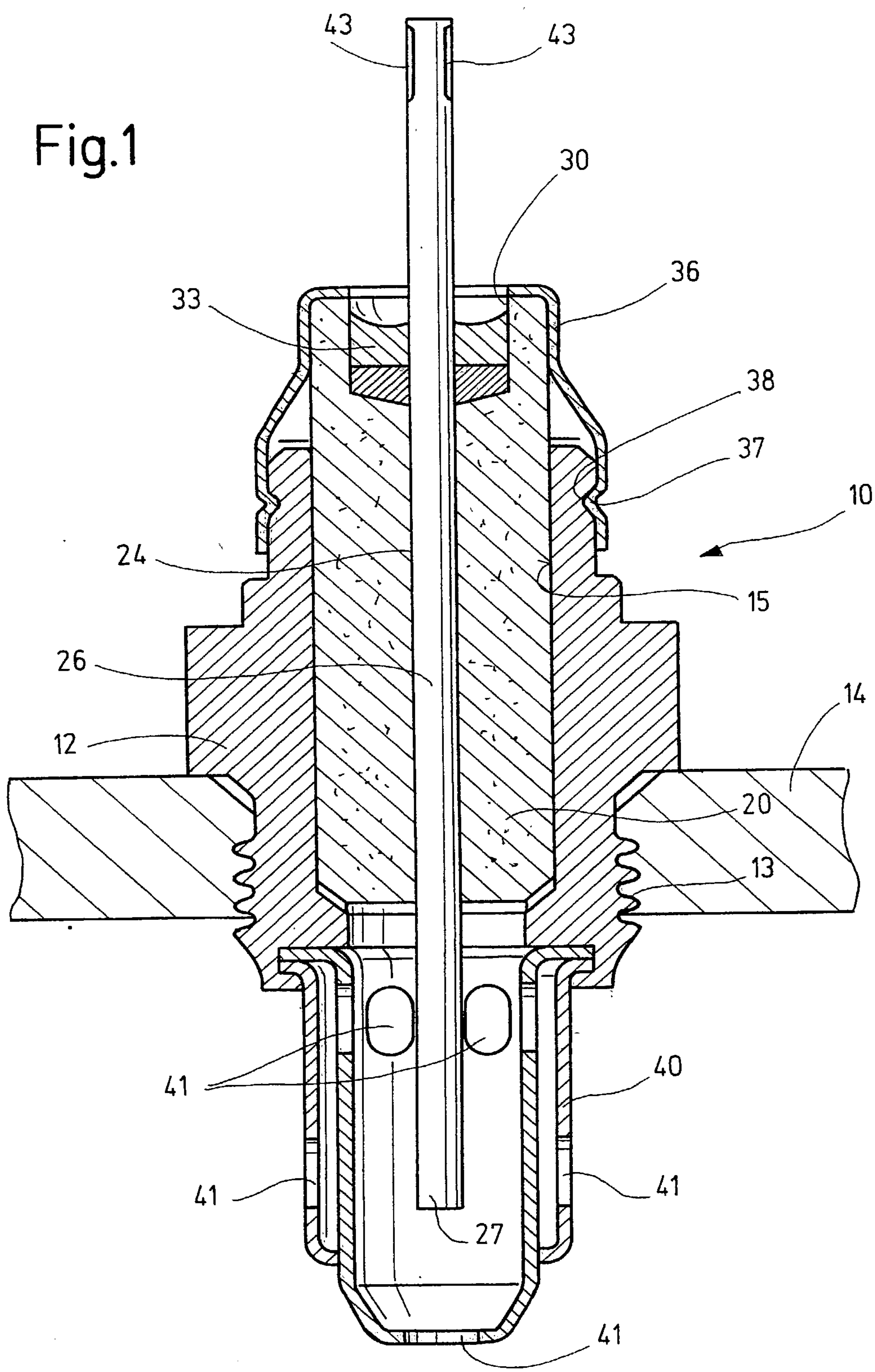
wherein the heating device (2, 2') is designed to reach the first temperature within a maximum heating time of five seconds.

Abstract

An exhaust gas sensor has a housing for installation in an exhaust gas line of an engine, having a heating device (2) and a sensor element (26) which is mounted in the housing and is heatable to a first temperature for measuring the exhaust gas. In a first operating phase, a heating power supply (5) supplies a high power for rapid heating of a component of the exhaust gas sensor (26), which is exposed to the exhaust gas, to a second temperature sufficient to ignite afterburning of the exhaust gas, and in a subsequent second operating phase supplies a lower power to keep the sensor element (26) at the first temperature.

Figure 2

Fig.1



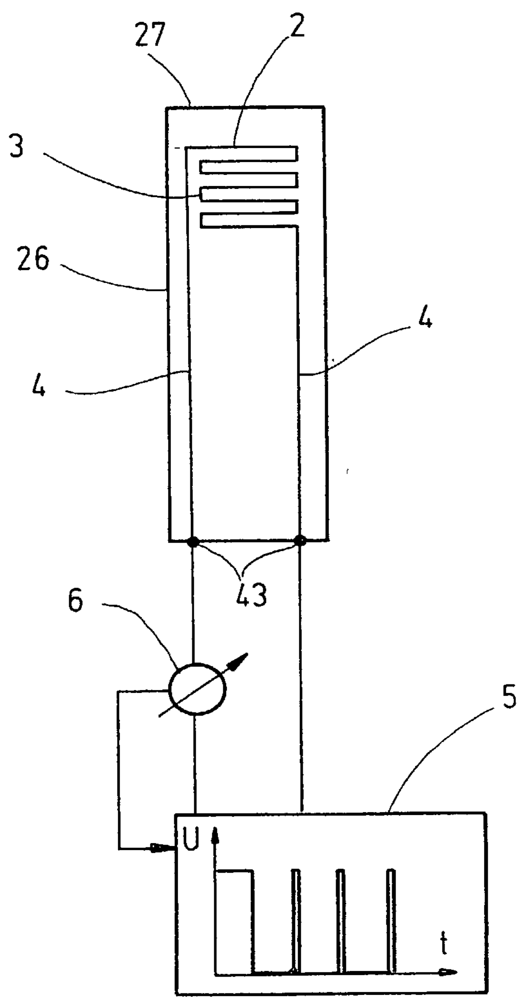


Fig.2

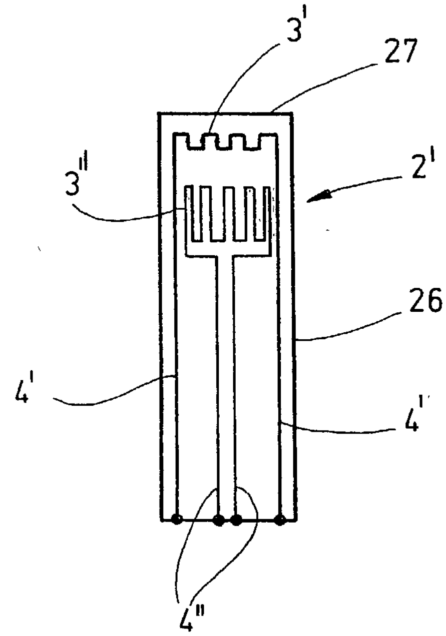


Fig.3

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COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am an original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **EXHAUST GAS SENSOR FOR IGNITING AN EXOTHERMIC REACTION**, the specification of which was filed as PCT International Application No. **PCT/DE00/02912** on **August 25, 2000**.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

Number	Country Filed	Day/Month/Year	Priority Claimed Under 35 U.S.C. 119
199 44 555.9	Federal Republic of Germany	September 17, 1999	Yes

EL039820633
~~EL594613272~~

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And I hereby appoint Richard L. Mayer (Reg. No. 22,490) and Gerard A. Messina (Reg. No. 35,952) my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

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Please direct all telephone calls to Richard L. Mayer at (212) 425-7200.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful and false statements may jeopardize the validity of the application or any patent issued thereon.

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